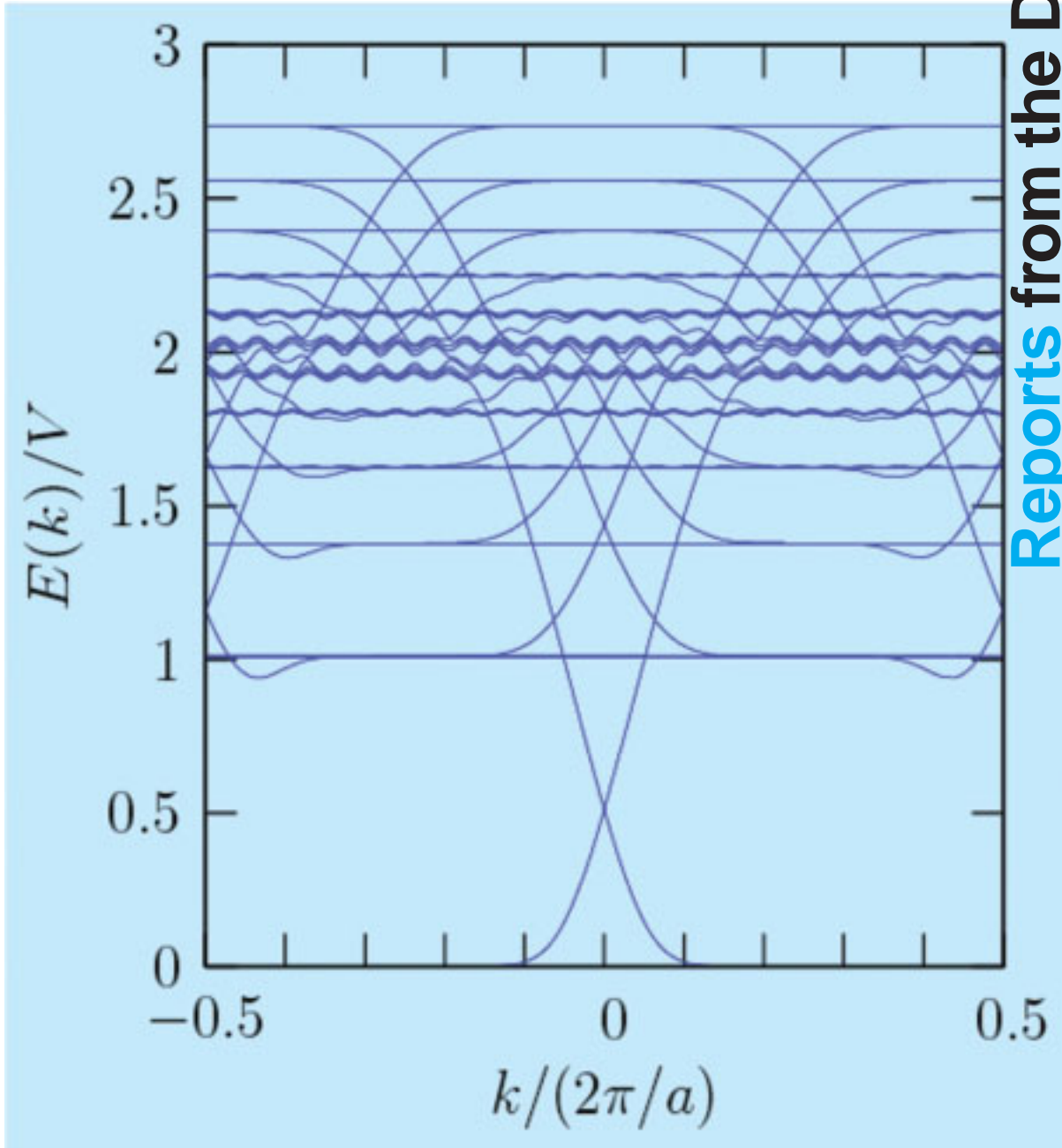
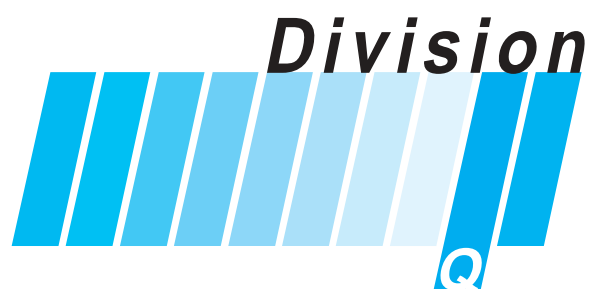


Scientific and Technical Cross-sectional Tasks



Reports from the Divisions



Scientific and Technical Cross-section

Division Q has a task consisting of two parts: On the one hand, it supports the technical divisions of the PTB through its scientific, technical and infrastructural services, on the other hand it works together with national and international partners on a scientific and technical level.

Without the support and services rendered to the other divisions - by more than 70 % of the Division's staff - the PTB would not be able to operate. The tasks in this field of work are, however, less suited for being described in an Annual Report. Therefore, this year too, we will place the emphasis on presenting our activities in the fields of work "Fundamentals of Metrology", "Metrology for Society" and "International Affairs".

Titelbild

Die elektronische Bandstruktur eines Gittermodells mit einer Flussdichte von $11/23$ eines Flussquantums h/e pro Einheitszelle für Energien $E(k)/V > 0$. Die waagrechten Linien entsprechen den *bulk*-Landaubändern. Dazwischen liegen die Energien der Randzustände, die bei den Impulsen $k/(2\pi/a) = 0$ und $\pm 0,5$ eine fast lineare Energie-Impuls-Dispersion aufweisen. Dieses Verhalten führt zu der im Experiment beobachteten ungewöhnlichen Quanten-Hall-Leitfähigkeit $\sigma_{xy} = -e^2/h(2n + 1)$, $n=0,1,\dots$

Fundamentals of Metrology

In Department Q.2 Theoretical Fundamentals, quantum-theoretical investigations have again stood in the foreground. These questions become all the more important, the more intensely nanotechnology and macroscopic quantum effects find their way into metrology. In this connection, there is also an unsolved measuring problem that has existed for many years, which always appears when quantum systems are brought into contact with classical systems. A recently published proposal for describing this interaction uses a universally applicable formalism which takes all possible configurations of the system into account. This new approach avoids not only some of the deficits of earlier approaches, but also allows a feedback effect on the classical system. Additional focal points are studies on phase transitions in Heisenberg antiferromagnets with anisotropic exchange on the triangular lattice as well as investigations of many-body effects in quantum dots. In this latter question, the functional renormalization group method is being applied increasingly which allows the approximative treatment of multiparticle systems and has already been successfully employed in tunnelling as well as with quantum wires and simple quantum dots. But also the quantum-Hall effect, which has been investigated for many years, surprisingly yielded new aspects in the period under report.

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ional Tasks

The discovery made about a year ago of an unusual quantum-Hall effect in single layers of graphite has produced new activities in this field worldwide. The Hall conductivity appearing in steps of $2e^2/h$ is currently explained theoretically through the movement of relativistic "massless Dirac fermions", which appear on a two-dimensional hexagonal carbon lattice at low energies. The great energetic distance between adjacent Landau bands makes this novel material highly interesting for metrological applications. With the magnetic flux densities possible today, the determination of the von-Klitzing constant should even be possible at room temperature. First one would have to check - with a very low uncertainty - whether the value of the quantised Hall resistance actually agrees with the value from conventional samples from semiconductor heterostructures. Based on theoretical investigations carried out in Department Q.2, it was possible to show that a similar behaviour of the Hall conductivity is to be expected also for electrons on a square lattice when the magnitude of the magnetic flux density lies close to a half flux quantum h/e per unit square (see cover picture on page 163). The calculations furthermore show that in the presence of microscopic disorder, the properties of the quantum phase transitions are different from those previously known in the conventional quantum Hall systems.

Many of the tasks arising in Department Q.2 - such as the description of systems with sev-

eral interacting particles or the investigation of single particle dynamics with scattering at random electrostatic disorder potentials - can only seldom be accomplished completely with analytical methods. Mostly, these admittedly difficult problems cannot be solved with approximation methods - not even in special cases. Therefore, more and more often it is necessary to carry out exact numeric model calculations in order to grasp situations which are particularly interesting from the physical point of view. A Linux cluster assembled recently in cooperation with Department Q.4 Information Technology is intended to aid in eliminating the bottle-necks having arisen in the available computing power in the past years. An openMosix extension of the operating system enabled the establishment of a virtual multi-processor machine composed of standard components linked to one another. An advantage of this architecture lies in the very good scalability which also implies that the cluster is easily adaptable to future tasks.

Metrology for Society

The implementation of the MID (European Measuring Instruments Directive) was intended to be coupled with an extensive reorganisation of legal metrology. As considerable discussions have delayed this project, the Bundesministerium für Wirtschaft und Technologie (BMWi) (Federal Ministry of Economics and Technology) has come to the decision that initially only the regulations of

Scientific and Technical Cross-sectional Tasks

the MID are to be implemented immediately through the supplements of the existing Verification Ordinance and that the further modernisation of legal metrology is to be carried out at a later date.

Despite a lacking national legal basis, the BMWi has appointed the PTB a notified body for conformity assessments according to the modules B, D and H1 in compliance with the MID so that the respective procedures for the manufacturers of measuring instruments could be carried out in time, before the MID came into force. These procedures were type examinations and design reviews carried out by the technical departments, as well as recognitions of quality management systems at the manufacturers' by the Certification Body for Measuring Instruments (ZS-M), which employs auditors from the PTB and the verification authorities for this purpose.

As regards the impact the MID will have on the manufacturers and users of measuring instruments and on the verification authorities and state-approved test centres, many questions remain open. In various internal and external events, PTB speakers have reported on the new measures in legal metrology and their consequences for the different target groups. In connection with the liberalisation of metrology, the public utility companies and the state-approved test centres were particularly interested in the tasks of the notified bodies in order to be better able to assess the investments for this sector.

With regard to the task of harmonising the application and interpretation of the MID, the European Commission assigned an important role to the cooperation within WELMEC (European Cooperation in Legal Metrology). The guidelines developed by WELMEC for the application of the directive for non-automatic weighing instruments and of the MID have found the approval of the Commission and are recommended for use on their Internet page. The guidelines, which were also influenced by the PTB, relate to interpretations and clarifications of requirements for instruments and authorities for carrying out the conformity assessments. The list compiled by WELMEC of those elements of international recommendations by the OIML (International Organization of Legal Metrology)

which are suitable for fulfilling the presumption of conformity in compliance with the basic requirements of the MID were also accepted by the Commission after consultation with the Working Group on European Measuring Instruments.

After the infrastructure had been established through the Central Body for Technology Transfer it was possible to present service offers from there directly to the customers. For the internal target group, informational events on patent utilisation and business start-ups took place at both sites. For external target groups, technological offers were presented for various sections of the economy. This included the presence at the trade fairs "Control" and "Optatec" as well as the Internet platform www.technologietransfer.ptb.de with various possibilities for downloading. Also an informational brochure as well as excerpts from the patent catalogue are available in printed form.

Due to intensified acquisition activities it was possible to conclude further licence agreements also for such patents for which it had been especially difficult in the past to find interested parties. As a result of the proof of competency which is provided by PTB through the patenting of technologies that have been developed at PTB, also third-party-funded projects were started - parallel to the licence agreements - so that the revenues of PTB could be increased in this field.

A successful technology transfer project took place in the area of business start-ups. The "Magnetic Marker Monitoring" method developed in the PTB for visually following the path of a tablet in the human body is being further developed by the SocraTec R&D GmbH company, whereby instruments of the PTB are made available for use, and a PTB employee who thus far had only had a limited employment contract can now establish a new sphere of business.

International Affairs

News which was especially pleasant for the PTB, Division Q, and particularly for Department Q.5 Technical Cooperation reached us in September 2006: The Bundesministerium für wirtschaftliche Entwicklung und Zusammenarbeit (BMZ) (Federal Ministry for Economic Cooperation and Development) will provide financing for the German project contribution "Promotion of quality infrastructures – sectoral, national, regional (PTB)" to the amount of EUR 3.8 m annually. This increases planning reliability and lowers administrative expense. This promotion contributes greatly to enabling the units of measure and product qualities in the developing and emerging countries to meet international standards as quickly as possible. Last but not least, this task represents recognition of more than forty years of successful cooperation between the BMZ and the PTB.